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Original article

One year changes in QCT and DXA bone densities following bariatric surgery in a multiethnic Asian cohort☆

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Abstract

Objectives: Bone loss after bariatric surgery is well recognized but the best method for quantifying bone mineral density (BMD) remains controversial. BMD measured with dual energy X-ray absorptiometry (DXA) is prone to measurement errors in this population while quantitative computed tomography (QCT) is less affected. We report the skeletal changes after bariatric surgery at 1-year in a multi-ethnic Asian cohort using both central DXA and QCT.

Methods: Areal BMD (aBMD) and volumetric BMD (vBMD) of twenty-two participants (mean age 40.6; female 59%) undergoing sleeve gastrectomy (n = 12) or gastric bypass (n = 10) were measured with central DXA and QCT respectively before and 12-months after surgery.

Results: Weight and BMI decreased significantly but discordant QCT and DXA results were noted. aBMD was significantly reduced at the total hip (TH) and femoral neck (FN) by 6.9 and 8.5% respectively but was not significantly different at the lumbar spine (LS). By contrast, there were no significant changes in vBMD at TH and FN. Instead, a significant 11.2% decrease in vBMD was noted at the LS. These findings were largely similar between the two surgical subgroups. Interestingly, cortical vBMD increased at both TH and FN while trabecular vBMD decreased at the TH. These changes were observed despite no significant post-operative changes in serum calcium, iPTH or 25-OH vitamin D levels.

Conclusion: Technical or physiological factors may be involved in the discordance between QCT and DXA results during short-term follow-up and the most suitable method of bone density measurement for post-bariatric surgery patients remains uncertain.

Keywords: Bariatric surgery; Bone mineral density; Quantitative computed tomography; Dual energy X-ray absorptiometry; Asian

1. Introduction

Obesity is a serious public health issue in Singapore with a rising prevalence from 6.4% in 2006 to 10.8% in 2010 [1], mirroring the world-wide trend [2]. Obesity is difficult to treat and current lifestyle interventions have limited efficacy [3]. Bariatric surgery is the most effective treatment for morbid obesity and more patients are undergoing bariatric surgery [4]. In addition to sustained long-term weight loss, bariatric surgery leads to dramatic improvement in a wide range of obesity-related conditions including type 2 diabetes mellitus

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[5−7], cardiovascular events [8], and even mortality [9]. Despite the improvement in metabolic health, a number of studies have consistently reported significant bone loss after surgery [10] and the concern of a greater fracture risk is supported by a recent population-based study that reported a 2.3 fold increase in fracture risk among patients who underwent bariatric surgery [11]. An accurate measurement of bone mass and bone mineral density is therefore required for optimal assessment and management of bone health.

At present, guidelines recommend the periodic measurement of BMD using dual-energy X-ray absorptiometry (DXA) after bariatric surgery [12,13]. However, the accuracy of DXA is affected by excess adiposity and changes in body tissue distribution during rapid weight loss [14−16]. Quantitative computed tomography (QCT) by contrast, is thought to be less affected [17] and may also aid with the estimation of trabecular and cortical bone changes. The majority of studies to date were performed using DXA except one study that used QCT for the evaluation of axial BMD in 30 patients who underwent Roux-en-Y gastric bypass (RYGB). This was the first study that used central QCT and central DXA in a gastric bypass population and they had reported discordant measurements between the two techniques at 12-months [18]. Studies that had used peripheral QCT in bariatric surgery patients reported different findings, with one study highlighting cortical bone loss [19] and another study highlighting preservation of volumetric density and bone strength [20]. These studies highlighted the technical difficulties in obtaining an accurate assessment of bone density in the bariatric surgery population and thus the most appropriate bone imaging modality for this subgroup remains debatable. It was also unclear whether differences between DXA and QCT would be observed in a different ethnic population and using other types of bariatric surgery techniques.

In this study, we aim to study the skeletal effects of bariatric surgery in a group of multi-ethnic Asian population using both central DXA and central QCT.

2. Methods

2.1. Subjects

Twenty-two participants (mean age 40.6; range 25.6−56.8 years) with BMI $\geq$37.5 or $\geq$32.5 kg/m^2 with obesity-related co-morbidities were recruited from the Singapore General Hospital's Obesity Metabolic Unit. Sleeve gastrectomy (SG) [21] or gastric bypass (GB) [22,23] was performed using laparoscopic techniques by two surgeons. The selection of bariatric surgery techniques was based on clinical criteria. Exclusions were weight >150 kg, thyroid dysfunction, active malignancy, significant cardiac or renal dysfunction, prior bariatric or complex abdominal surgeries and usage of medications that could alter bone metabolism (e.g. bisphosphonates, parathyroid hormones, estrogen, activated vitamin D and glucocorticoids). Nutritional guidelines by the American Association of Clinical Endocrinologist, The Obesity Society, and American Society for Metabolic & Bariatric Surgery [12] and American Endocrine Society [13], were adapted to our local practice to actively correct vitamin D deficiency before surgery and to supplement calcium and vitamin D after surgery. Individuals with vitamin D deficiencies were treated with oral ergocalciferol (vitamin D2) 50,000 IU three times per week for two weeks before surgery and participants received supplements with oral elemental calcium 1000 mg/day and ergocalciferol 50,000 IU per week after surgery. Institutional Review Board approval and written informed consents were obtained before the start of the study.

2.2. Hormone and substrate measurements

Blood samples were obtained from study participants after an overnight fast of 8 hours. To avoid analytical variation, serum and plasma were stored at −80 °C and analyzed in batch after completion of the 1-year follow-up. Serum total 25-hydroxy vitamin D (25-OH Vit D) was measured using carbonylmetalloimmunoassay (Abbott Diagnostics, Wiesbaden, Germany) and intact parathyroid hormone level (iPTH) using electrochemiluminescence immunoassay (Roche Diagnostics, Indianapolis, IN, USA). Serum Type I collagen C-telopeptides (CTX) fragments was measured using enzyme linked immunosorbent assay (Immunodiagnostic Systems, Boldon, United Kingdom), while sclerostin, osteocalcin, osteopontin and osteoprotegrin were measured using the Milliplex bone metabolism assay (HBNMAG-51K, Millipore, St. Charles, MO, USA).

2.3. Bone mineral density

Areal bone mineral density (aBMD, g/cm^2) at the lumbar spine (L1-L4), total hip (TH), left femoral neck (FN) and whole body were measured using DXA (Hologic Discovery Wi densitometer, Hologic, Inc, Massachussets, USA). QCT measurements of volumetric bone mineral density (vBMD, mg/cm^3) were obtained at the lumbar spine (L1-L2) and proximal femur (General Electric VCT LightSpeed 64 Slice CT, General Electric Healthcare, Waukesha, WI, USA). Three-dimensional images were reconstructed and analyzed with QCTPro software (Mindaways Software, Inc., Austin, TX, USA).

2.4. Statistical analysis

The data was examined for normality of distribution. To examine the post-surgical changes, paired *t*-test and the Wilcoxon matched-pairs signed rank test were used for normally and non-normally distributed continuous variables respectively and Chi square test or the Fisher's exact test were used for categorical variables. Comparisons between surgical subgroups were made using unpaired *t*-test. All analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). Data are represented as mean ± standard deviation or as percentage as appropriate. A two-tailed p value $\leq$ 0.05 was considered statistically significant. Study data were collected and managed using REDCap electronic data capture tools hosted at the Singapore General Hospital.